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Comparative Risks of Microbiological Contamination of Indoor Air And the Role of Social Amplification of Risk

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Abstract

Risk researchers have identified a relationship between risk events and the stigmatization of places, facilities, technologies and products. Such stigmatization can be an important vehicle of secondary and tertiary risk consequences. In fact, stigma-induced consequences from socially amplified risks can eclipse those involving biophysical effects. Past research upon stigmatization of people and processes provides the conceptual basis for the explanation of the social amplification of risk model.

Using the examples of *Staphylococcus aureus* [a microbiological health hazard that is not subject to stigmatization] and *Stachybotrys chartarum* [a potential but unproven microbiological hazard that has been the subject of widespread media attention], this paper will characterize the factors that effect the emergence, consequences and durability of risk-induced stigma.

Introduction

Each day people are confronted with new information about potential dangers to their health and safety. The alleged danger may be attributed to industrial sources of pollution near their home, the cellular telephones they use to communicate, the design features of the car they drive, the prescription drugs they take, the chemicals in their water they drink, bioengineering of the foods they eat, or the contaminants in the air they breathe.

Ironically, as our society has expended a great deal of time and money to make life safer and healthier, many members of the public have become more, rather than less, concerned about risk. They see themselves as exposed to more serious risks than were faced by Americans in the past, and they believe that this situation is getting worse rather than better. In other words, modern culture is preoccupied with the elimination of risk as the elimination of scarcity preoccupied the attention of industrial and pre-industrial society.

Risk Assessment

There are sharp contrasts between the general public's perception and ranking of risk and the opinions held by scientists and government regulators (1). Risk perception studies have

attempted to explain these disparities, and have focused on identifying factors that shape the public's attitudes and deeply held beliefs.

It seems that the risk dilemmas we face today are due to the poor fit between solutions of the past, based on approaches developed by cultural experiences with problems of earlier times and the need for solutions to the risks that we deal with today. The major tools that dominate risk assessment and management strategies were taken from the fields of public health, toxicology and engineering. They serve to highlight some parts of the risk equation while obscuring others. Scientists and experts find this quantitative, health-based approach appealing. The public, in general, does not. The concept of the social amplification and attenuation of risk is one way to re-frame the risk analysis process factoring in public perceptions, values and priorities.

A new paradigm

In 1988, Kasperson et al developed a new paradigm, which they termed the "social amplification of risk"(2). Within this framework risks are seen as interactive, involving both the biophysical and social worlds. Risk includes threats of harm to people and nature as well as other things or ends that people value, such as community or political freedom. Thus risk is represented by the joint product of impacts on human health and nature and disruption in social systems and value structures. The net result includes both the experience of potential harm and the interpretation of these threats by people and institutions. These interpretations generate rules by which society and its subgroups select, order and explain signals concerning the threats emanating from human activities. Risk analysis, therefore, requires an approach that is capable of illuminating risk in its fullest complexity, is sensitive to the social settings in which risk occurs, and also recognizes that social interactions may either amplify or attenuate the signals to the public about the risk.

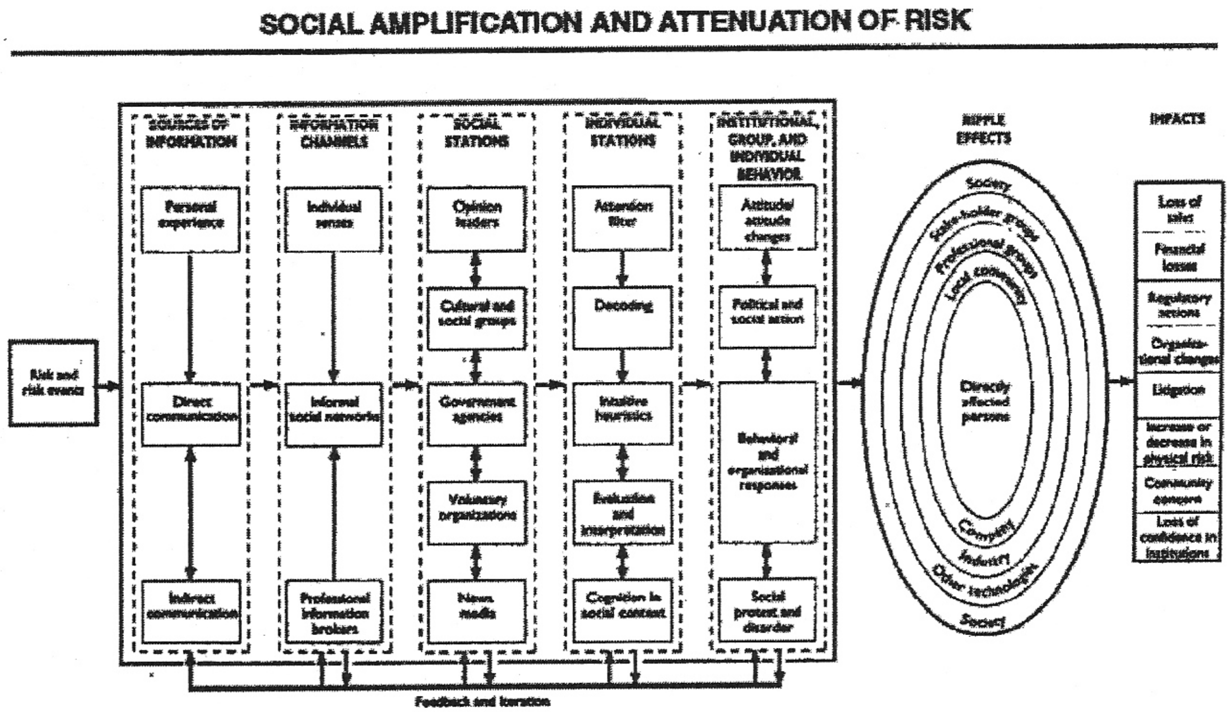

Figure 1 (from Kasperson RE and JX Kasperson; The Social Amplification of Risk. The Annals of the American Academy of Political and Social Science; May 1996)

Stigma is attached to risks that public sentiment views as so atrocious or dreaded that they are vilified beyond rational interpretation, thus perceptions far outweigh the actual biophysical hazard attributable to them.

Factors that affect risk perception

The cycle of social amplification or attenuation includes a number of aspects. It may begin with an actual event, such as an industrial accident or chemical release. It may be purely informational in nature – such as the release of statistics on the frequency and causes of accidental car airbag inflations. Or a public interest group with a political agenda issues a press release on a health threat associated with a consumer product.

Since the public learns about risk and risk events through information systems rather than through direct personal experience, the mass media (television, print, and internet) is a primary source of risk communication. But it is far from a neutral source of factual data. Communication of a risk is far more involved than the simple depiction and conveyance of information. The mere fact that a risk is considered significant enough to warrant media coverage and is thus brought to the attention of the community begins to influence public opinion about the risk. Particularly important in shaping group and individual views of risk are:

- the extent of media coverage
- the volume of information provided

- the way the risk is framed
- the way messages concerning the risk are interpreted
- the use of symbols, metaphors and adjectives

All are important factors that determine whether a risk will be highlighted (and potentially stigmatized) or downplayed.

Mass media plays many roles in our society – as entertainers, risk watchdogs, gatekeepers and agenda setters. The media covers risks selectively, prioritizing those events that are rare and sensational [have story value], giving them disproportionate coverage while minimizing more commonplace but often more serious risks such as chosen behaviors [overeating, smoking] or well-known hazards [handguns, car accidents]. In other words, risk and risk events compete for scarce space in the media's attention, and the outcome of this competition is a major determinant of whether a risk will be socially amplified or attenuated in society's processing and disposition of the risk.

The channels of information impact perception of risk, with different weight given to personal sources [acquaintances], specialized sources [professionals] and general sources [mass media]. The more informal, personal sources of risk information include the network of friends and neighbors on whom individuals rely as reference points for validating perceptions and contextualizing risk. This is likely to be an extremely important influence on the value or significance a person puts on a risk.

Social institutions, organizations, corporate entities and professional associations also occupy primary roles in determining how the general population handles risks, for it is in these contexts that most risks are conceptualized, identified, measured and managed. These organizations vary widely in their goals for and commitment to risk management.

Risk issues are also important elements in the agendas of social and political groups such as non-governmental organizations [such as the Sierra Club, Greenpeace, Green Coalition], which focus on environmental and health concerns. The nature of these groups also shapes the definition of risk problems – framing the context, rationality, interpretation and the selection of management strategies.

Political campaigns may also bring risks to public attention, attempting to polarize views and attract allies to their position and political party.

The information system [consisting of personal experience, communications from mass and personal sources] brings risk to the attention of the population. The social stations (news media, professionals, opinion leaders, cultural and social groups, government agencies, non-governmental agencies] process the risk and transmit signals to the population about the seriousness of the risk and the performance of risk management institution. The degree of amplification or attenuation will affect the extent to which risk "ripple effects" accompany the risk or risk event.

Where social concern and debate are intense, secondary and tertiary impacts on society beyond those immediately involved may occur, extending to the local community, professional groups, stakeholder groups and ultimately to society as a whole. These effects may include:

- enduring mental perceptions, images and attitudes [increasing distrust of government, corporations or other institutions; anti-technology attitudes; social apathy]
- adverse impact on local or regional economy [decreased business sales and property values]
- political or social pressures [demands for change in the political climate or adverse impact on popularity of political leaders]
- social and community conflict
- changes in government regulations
- increased insurance costs
- litigation
- repercussions for other technologies, products or places [related in some way to the risk or risk event]

Thus the impact of risk and risk events often exceed the direct physical harm to the involved people or ecosystems and includes more indirect effects on the economy, social institutions and societal attitudes. The extreme consequence of this effect is stigmatization.

Alternatively, a dampening and constraining of risk effects due to shrinking of ripple effects may result from the attenuation of risk by social processes. It frequently cannot be determined beforehand whether the biophysical impacts will be the predominant adverse effect or whether they will be eclipsed by amplification-driven impacts and ripple effects.

Where the potential for stigma to become attached to certain technologies exists, the significance of secondary impacts is even greater. Negative imagery and emotional reactions can become closely associated with the mere thought of certain technologies, products, and places, which become tainted objects to be shunned and avoided. The effects on public acceptance of a technology, its facilities and products, and the places in which it is located can be far-reaching. Nuclear energy and hazardous waste facilities are primary examples of stigmatized technologies embroiled in controversy and public opposition. Contributing to such effects are: public perceptions of great risk, intense media coverage of even the most minor incident, distrust of the managers involved, social-group mobilization and opposition, conflicts over value issues and disappointments with failed promises.

Two microbial agents will be used to illustrate the processes of social amplification and attenuation of risk.

	Staphylococcus aureus	***Stachybotrys chartarum (atra)***
Toxin	+	+
Microscopic	+	+
Reliably identified	+	+
Confirmed Human Pathogen	+	-

Found in homes	+	+
Present on surfaces	+	+
Present in air samples	+	+
Present in dust	+	+
Respirable size particle	+	?
Cluster outbreaks	+	+
Can cause severe disease	+	-
Toxigenic dose	**Less than 1.0 mg.**	+
Can cause death	+	+
Carcinogen	-	-
# People affected per year	**Millions**	**Few**
Medical knowledge	**High**	**Low**
Reliable Diagnostic tests	**Yes**	**No**
Physician concern	**High**	**Low**
Public concern	**Low**	**High**
Media attention	**Rare**	**Intense**
Repercussions	**No**	**Yes**
Change in industry practice/ Guideline/regulation	**No**	**Yes**
Adverse impact on industry	**No**	**Yes**
Adverse impact on property value	**No**	**Yes**
Stigma	**No**	**Yes**
Political/Social issue	**No**	**Yes**
Increased insurance costs	**No**	**Yes**
Generates Litigation	**No**	**Yes**

Table 1

Example

Staphylococcus aureus is a hardy bacterium that is microscopic in size. It cannot be detected by the unaided eye, and thus foodstuff, surfaces or products that are contaminated with the organism cannot readily be identified and avoided. It is easily and definitively identified by microscopic examination of contaminated materials or biological specimens, laboratory culture, and DNA in-situ hybridization. Some strains produce a highly heat-stable toxin that causes illness in humans and enhances virulence. Consumption of food contaminated by *Staphylococcus* causes food poisoning. Other diseases caused by *Staphylococcus* include toxic shock syndrome [a disorder characterized by multisystem organ failure and high mortality] and scalded skin syndrome [extensive blistering of large areas of skin](3).

Infectious diseases caused by *Staphylococcus* include skin infections, bacteremia, endocarditis, arthritis, osteomyelitis, pneumonia and abscesses in virtually any organ.

The toxogenic agents include catalase [which interferes with the ability of neutrophils (white blood cells) to kill the bacteria]; coagulase [which causes blood to clot]; hyaluronidase [which destroys connective tissue and facilitates the spread of infection]; protease [which enhances the effectiveness of coinfections like viruses and increases morbidity]; and urease [which alkalinizes the urine and increases the likelihood of urinary tract infection]. It also produces 4 different red cell hemolysins, [which destroy red blood cells]; a dermonecrotic toxin [breaks down the skin]; a toxin that inhibits water absorption [which increases diarrhea]; a leukocidin [which lyses

neutrophil and macrophage (white blood cell) membranes]; two exfoliatin toxins [which also cause skin damage and are responsible for the "scalded skin syndrome"]; 5 distinct enterotoxins [which increases peristalsis and cause vomiting by affecting the central nervous system]; two toxic shock toxins, [both of which act to stimulate cytokine release, resulting in hypotension, conjunctival (eye) and skin damage and fever, enhance the production of tumor necrosis factor, IL-1, Il-2, colony stimulating factors and interferon gamma]. (4).

Staphylococcus is ubiquitous in homes, schools, and hospitals and in virtually all places that humans occupy. It is present on surfaces, in dust and in the air. It is most often spread person-to-person, but can be spread through contact with contaminated surfaces, via inhalation and by consuming contaminated foodstuffs.

Cluster outbreaks of toxin mediated disease are identified frequently - in hospitals, picnics, etc. (food borne illness); newborn nurseries, daycare centers and burn units (scalded skin syndrome); and in young women who use tampons (toxic shock syndrome). Outbreaks are associated with a very high attack rate (often greater than 75% of the population at risk), high acute morbidity and significant mortality (5). Symptoms associated with food poisoning include nausea, vomiting, abdominal cramping, prostration, diarrhea, headache, muscle cramping and hypotension. Symptoms of scalded skin syndrome include a rash, which may develop flaccid blisters, which may be localized, or spread to involve the entire skin surface. Complications include a high rate of secondary infections, fluid and electrolyte loss and high mortality. Toxic shock syndrome is associated with the use of hyper absorbent tampons, post-operative wounds and childbirth (both

vaginal deliveries and cesarean sections) and includes high fever, a diffuse rash that blisters on the palms and soles, hypotension (low blood pressure), and vomiting, diarrhea, kidney or liver dysfunction, blood clotting abnormalities, muscle aches and disorientation (central nervous system dysfunction).

The infective dose is well established. A toxin dose of less than 1.0 microgram will produce symptoms of staphylococcus intoxication. This toxin level is reached when the *S. aureus* population is 100,000 per gram of contaminated material (6).

An estimated 3 million people in the United States contract food poisoning due to *S. aureus*, although the number may be substantially higher (7). Hundreds of cases of scalded skin syndrome and dozens toxic shock occur worldwide each year.

Conclusive testing linking an environmental agent to human disease consists of detection of the toxin in the suspect food (or other agent), either via serologic examination, direct microscopic examination of the food, monoclonal antibody testing or phage or DNA typing, and similar testing of the bodily fluids (which in some cases will also involve a positive culture for the organism) of affected victims.

There is no in-vitro, animal or epidemiological data to suggest that it is a carcinogen.

Thus, *S. aureus* is a an agent that is invisible (microscopic), produces toxins, can be reliably identified by scientific methods both in the environment and in people affected by it, is a confirmed human pathogen, causing both infectious and toxigenic disease, is found in homes, is present on surfaces as well as in the air and dust. It is of respirable size (can be breathed in). Cluster outbreaks as well as individual cases occur. The diseases it causes are severe and may be fatal, although it does not cause cancer. The dose required to cause disease is known. Millions of people are affected by it. Medical knowledge about the agent, the diagnosis, assessment and treatment is extensive. The tests used to detect and diagnose the illness are reliable, readily available and FDA approved. Physician concern about the agent (especially infectious diseases caused by drug resistant strains) is high.

On the other hand, the public is somewhat familiar with this agent but not particularly concerned by it. It gets infrequent media attention, and when it does, the media does not tend to dramatize the incident with metaphors. There are typically no repercussions from a case or cluster of illnesses caused by staphylotoccal toxins – in that industry practices are not changed, and no new regulatory or scientific guidelines have been formulated to deal with it. There has not been any adverse impact on any industry due to *Staphylococcus* induced illnesses, and property values are not adversely impacted. Insurance premiums do not increase due the presence of *Staphylococcal* organisms in buildings or from the diagnosis of staphylococcal disease. Litigation is never generated from the presence of *Staphylococcus*.

Stachybotrys chartarum (atra) is a fungus of the Ascomycetes classification. Its spores are microscopic in size and it produces a variety on mycotoxins, including trichothecene such as the satratoxins, verrucarol, verucarins, triverrins, roridin E and vomitotoxin (8). The primary mechanism of action of the tricothecenes appears to be inhibition of protein synthesis (9). Animals given massive doses of spores intranasally develop severe pulmonary injury, depletion of lymphoid tissues [due to damage to white blood cells] and hemolysis [damage to red blood cells](10). The spores are reliably identified in environmental samples by microscopic examination and growth in culture. Although several outbreaks of illness in humans have been attributed to respiratory exposure to *S. chartarum*, the causal link between fungal contamination in the indoor environment and adverse health consequences has yet to be established (11). *S. chartarum* is found in homes, schools and in other buildings that humans occupy, and can be found in dust, surfaces and in air samples. It is respirable in size. Anecdotal cases suggest that at very high levels of exposure, generally associated with agricultural activities, *S. chartarum* can cause severe but generally self-limited illness (12).

In contrast to *S. aureus*, diseases linked to *S. chartarum* exposure in indoor environments are less severe, generally consisting of nonspecific symptomatic complaints of flu symptoms, sore throats, diarrhea, headaches, fatigue, malaise, and "difficulty thinking". Disease endpoints and abnormalities in medical parameters have not been consistently observed, so there is no uniform case definition or diagnostic criteria for the disease. Some studies have reported defects in lung function, decreased white blood cells, antibody formation, and immune parameters while others have not (13). There is no definitive diagnostic test. The amount of spores or toxin that is needed to produce disease is unknown, although studies in the agricultural setting show that farmers exposed to 10^{10} spores/m^3 (10,000,000,000) are adversely affected by their exposures, whereas those exposed to 10^8spores/m^3 generally are not (14). Data linking exposure with

health effects is unavailable for spore concentrations found in typical indoor air environments. Its relationship to the development of pulmonary hemorrhage and death in infants, while receiving widespread media attention, remains unproven. Only a handful of studies and case reports can be found in the medical literature, and these have been criticized as lacking as not having adequate data to support a claim of cause and effect.

Although physicians have experience with other diseases due to mold (both infectious and allergic), they, in general have limited concern about disease attributable to this organism.

Again, in comparison, the general population and the media's interest and concern about *S. chartarum* is high. Special interest groups, such as those involved ongoing litigation or the threat of litigation, often initiate media coverage. This inflates and stimulates controversy, often employing highly inflammatory metaphors and adjectives, such as "deadly"," poisonous" and "killer" mold. There is no animal or epidemiologic evidence to indicate that *S. chartarum* is a carcinogen, yet the popular press continues to raise this threat as if it was a proven fact.

Consequences of Amplification

Repercussions stemming from the notoriety of this mold have been far-reaching. The investigation of childhood deaths linked to *Stachybotrys* resulted in widespread, frequently acrimonious scientific debate that often found its way onto the front pages of newspapers. The mold has also been the subject of television and news programs. Extensive fear and public outcry result when the mold has been found in schools, dividing parents, teachers and school administrations. This social and community conflict put pressure on elected officials at local, state and federal levels. It has also lead to the development and implementation of policy agendas – the involvement of the EPA, Tools for Schools, and even testimony before Congress requesting for additional funding. Self-proclaimed medical and scientific experts have emerged, and regularly appear in newspapers and on television programs as well as proffering themselves as expert witnesses in legal proceedings.

Conferences were held that dramatically altered industry practices, transforming mold clean-up from standard and routine cleaning activities to expensive and complicated methods used for asbestos abatement. Guidelines were introduced by various professional groups [New York City Guidelines for the Removal of *Stachybotrys Chartarum*, AIHA, ACGIH] that required extraordinary precautions despite the lack of clear-cut health hazards. Changes in government regulations are contemplated as well.

Industrial hygienists and other "experts" who represent the interests of litigants have advised the closure of numerous public buildings (courthouses, banks and schools), and have counseled homeowners to move out of homes in which the mold has been found. Most of these buildings have not reopened and have been permanently stigmatized. Property values of both commercial and residential buildings in which *S. chartarum* has been found have plummeted.

Some industries have capitalized on the financial opportunity associated with evaluation and management of this risk. New schools and teaching programs have arisen to teach building professionals, home and building renovators, restoration personnel and Industrial hygienists how to develop and implement mold abatement projects. Insurance companies have been pressured to cover these more expensive abatement services, and have raised insurance premiums accordingly. New commercial testing laboratories have been established in order to handle the exponential increase in demand for mold testing. New organizations have been created to regulate and to address quality control in this industry.

And, yes, it has generated lawsuits. People with alleged injuries due to the mold, building owners who have discovered the presence of the mold and innumerable related parties have generated an enormous amount of expensive litigation. This group includes anxious, angry people who believe that they have been victimized by the unscrupulous actions of others and demand both accountability and retribution. These highly emotion-ladened situations play well on television and create enduring images that serve to personalize the risk, and shape enduring mental perceptions and attitudes.

Recently the scientific controversy led to a full investigation of all of the data by prominent medical experts in the Department of Health Services and in academia. The Centers for Disease Control issued a formal statement retracting their position on the association between *S. chartarum* and infant deaths – an unprecedented event. Yet this did little to derail events already in progress, which, having developed a full head of steam were speeding along, far outpacing their limited scientific underpinnings.

The consequences of having the public embrace a concept that has yet to be proven scientifically (that dreaded, severe health hazards are due to an agent found in the air of their homes, schools and jobs) will be an increasing distrust of physicians, scientists, government, corporations and other institutions. It will reinforce anti-technology attitudes. The reputation of evidence-based scientific reasoning will take another devastating hit, causing its somewhat shaky acceptance by the community to deteriorate further. The chasm between risk assessors and their constituents will deepen as the public perceives that they have been misled, or that their risk valuations are not shared by those responsible for managing these risks.

Conclusions

The social amplification of risk as illustrated by the contrast between how society view the dangers posed by *Staphylococcus* and *Stachybotrys* provides convincing testimony of the intertwining of physical and social phenomena in the makeup of risk and why our culture responds as it does to different characterizations of risk. As the public becomes increasingly preoccupied with eliminating risk, competing forces and agendas will play an increasingly greater role. Risk issues are rarely about risk alone. Future risk management decisions will have to take into consideration how society values the future, nature and human well-being; the

extent to which those most at risk should be protected; how risk reduction should best be balanced against economic gain and technological progress; and how much trust should be accorded both self-appointed "experts" and science-based risk managers. A careful assessment of the sources of information, information channels, institutional, group, and individual behaviors will provide important cues to anticipated ripple effects and the ultimate impact of risk on society.

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